Ring Body and Supporting Structure of Vibratile Gyroscope

1. Field of the Invention:

The invention is to provide a ring body and supporting structure of vibratile gyroscope, and more particularly to a vibratile ring-shaped gyroscope that arranges a supporting structure at the axial side of the ring body.

2. Background of the Invention:

Gyroscope is a device that measures rotary angle or angular velocity by the principle of inertia. Although the structure of a vibratile gyroscope is simple, its performance is still outstanding. Since there is no rotary part (e.g., bearing, etc.), so it is extremely suitable to be manufactured by the technology of micro-process. Currently, there are many kinds of micro gyroscope on the market. Since the micro gyroscope has the advantage of low cost and the characteristic of medium, high performances with further tiny size, so it has extremely wide application range, such as: satellite navigation and orientation system. Micro gyroscope is a sensing element extremely having potential of development and commercialization.

Except the restriction of signal-to-noise ratio with respect to the signal pick-up circuit, another major factor influencing the performance (sensitivity) of the micro gyroscope is the design of its configuration. In various configurations of vibratile gyroscope, since ring-shaped vibratile micro gyroscope has a cyclic symmetry structure, relatively, it has higher sensing sensitivity and the advantage of reducing the interference of surrounding vibration and the influence of temperature variation. However, under the premise of ring-shaped (circular) axially symmetric configuration, the performance of ring-shaped vibratile micro gyroscope may be differentiated due to the different design of its partial structure.

First, please refer to Fig. 1, which shows a prior structure of ring-shaped vibratile micro gyroscope (US Patent No. 5,450,751). The micro

gyroscope 10 is arranged in a base 12 and is comprised of side ring 14, central column 15, and plural semi-circular supporting structures 16 distributed divergently and equidistantly. Plural electrodes 13 are arranged around the outer surrounding of the side ring 14. The side ring 14 and supporting structures 16 are all manufactured by the techniques of micro mechanical electrical process with high depth-to-width ratio. The structural height of side ring 14 is the same as that of the supporting structure 16. Through using different areas of the side ring 14 respectively, the micro gyroscope 10 provides the inductive areas needed by static-electrically driving and capacitance sensing electrodes. Its inducing method is achieved by making different sections of the side ring 14 induced with plural sensing/driving electrodes 13. So, it must depend upon the side ring 14 having greater height to provide larger effective acting area. However, in the meantime of raising the height of side ring 14, it may also accompany with the increase of structural strengths of the side ring 14 and the supporting structure 16 such that, under the operations of same static-electrically driving force and induced Coriolis force, the deformation of side ring 14 is reduced, so the structural radial deformation of micro gyroscope 10 (i.e., its sensing rate) is lowered down, and this is disadvantageous for raising its sensing sensitivity. Additionally, since the supporting structure 16 must occupy the inner side of the ring body 14, so it is disadvantageous to install electrodes at inner side and outer side of the ring body 14 simultaneously.

There are prior arts cited, such as: "Angular Velocity Inductor" (ROC Patent No. 457370, US Patent No. 6,828,958 B1), "Angular Velocity Inducing Device" (ROC Patent No. 507077), etc., having the same structure as above-mentioned micro gyroscope 10, of which supporting structure are arranged at the inner side of the ring. Since they have substantially the same structures, repetitious description is not presented herein.

Again, please refer to Fig. 2, which shows the structure of ring-shaped vibratile micro gyroscope according to prior arts. The micro gyroscope 20, arranged in a base 22, is mainly comprised of ring body 24 and plural supporting structures 26. The main difference between this structure and the prior structure of Fig. 1 in the aspect of structural configuration is that its supporting structure 26 is divergently distributed around the ring body 24, so

the radial area of entire micro gyroscope 20 is expanded; therefore, it must occupy larger using space.

Summary of the Invention

Therefore, according to the shortcomings of the prior arts, the main objective of the invention is to provide a ring body and supporting structure of vibratile gyroscope. The supporting structures are located at axial side of the ring body and connect the ring body and the base for providing axial and radial supporting capabilities. The main vibratile ring body is restrained, such that it possesses preferable sensing sensitivity and capability to resist environmental vibration and noise.

The secondary objective of the invention is to provide a ring body and supporting structure of vibratile gyroscope, wherein a reinforcing structure is arranged at inner side and/or outer side of the ring, such that the partial rigidity of the ring body is enhanced to maintain an elliptical resonance mode.

Another objective of the invention is to provide a ring body and supporting structure of vibratile gyroscope, of which supporting structure is arranged at axial side of the ring, so it is advantageous to arrange electrodes at inner and outer sides of the ring to increase the effective sensing areas of the electrodes and the ring body hence enforces the capabilities of driving and sensing signals.

The further another objective of the invention is to provide a ring body and supporting structure of vibratile gyroscope, of which supporting structure is arranged at axial side of the ring, such that the occupying area of the ring-shaped gyroscope may be reduced.

Brief Description of the Drawings

Fig. 1 is a structural illustration of a micro gyroscope according to prior arts.

Fig. 2 is a structural illustration of another gyroscope according to prior arts.

Fig. 3 is a 3-D view of the outer appearance of a gyroscope according to the invention.

Fig. 4 is a 3-D view of the partial outer appearance of a gyroscope according to the invention.

Fig. 4A is the A-A cross-sectional view of Fig. 4 according to the invention.

Fig. 5 is a top view of the gyroscope according to the invention.

Fig. 6 is a vibratile illustration of the gyroscope according to the invention.

Fig. 7 is a 3-D view of the outer appearance of another preferable embodiment according to the invention.

Fig. 8 is a 3-D partial view of further preferable embodiment according to the invention.

Fig. 9 is a 3-D view in which a partial structure of further another preferable embodiment according to the invention incorporates electrodes.

Fig. 10 is an axially cross-sectional view of the embodiment of Fig. 9.

Detailed Description of the Invention

For your esteemed members of reviewing committee to further recognize and understand the characteristics, objectives and functions of the invention, a detailed description incorporating corresponding drawings is presented as follows.

Please refer to Fig. 3 through Fig. 4A, which show a ring body and supporting structure of a vibratile gyroscope according to the invention. The vibratile ring-shaped gyroscope 30 is arranged in a base, which is arranged in carriers, such as: satellite navigation and orientation system, etc. To show the structure of the vibratile ring-shaped gyroscope 30 clearly, the

base is not shown. The vibratile ring-shaped gyroscope 30 is mainly comprised of a ring body 31 and supporting structures 32. The ring 31 body is a sheet-shaped circular ring having an axial height H1. The supporting structure 32 is arranged at two corresponding axial side edges of the ring body 31. The supporting structure 32 is constructed by equidistantly arranging plural arc bodies 321 having same radius as that of the ring body 31 axially at two corresponding side edges of the ring body 31. Surrounded by the arc bodies 321, a ring-shaped contour is constructed. At least one connecting part 322 is arranged between each arc body 321 and the ring body 31. By the connecting part 322, it may make the arc body 321 fixed integrally to the ring body 31. A connecting part 323 is respectively arranged at two ends of one side, far from the ring 31, of each arc body 321. The arc body 321 is connected fixedly to the base by this connecting part 323, such that the entire vibratile ring-shaped gyroscope 30 may be arranged in the base. Since the ring body 31 is connected to the arc bodies 321 through the connecting parts 322 in points' manner, such that the ring body 31 is fixed between two upper and lower supporting structures 32 in suspending arm type, so it may restrain the ring body 31 from upward and downward motions, and it is possible to maintain the ring body 31 to have a predetermined radial deformation and vibration.

In order to promote the partial rigidity of the ring body 31 and maintain an elliptical resonance mode, there is a reinforcing structure 33 arranged at the inner side wall of the ring body 31. The reinforcing structure 33 is a fin-like structure projecting out radially in equal width from the center of the inner side wall of the ring body 31. Corresponding to the connecting part 322 between the arc body 321 and the ring body 31, the reinforcing structure 33 is arranged recessing part 331 that is shown as opening gradually divergent outward from the ring 31 in side radial direction.

Please refer to Fig. 5, wherein the vibratile ring-shaped gyroscope 30 has a circular ring body 31. There are eight sections of arc bodies 321 arranged axially and equidistantly at the side edge of the ring body 31. A fin-like reinforcing structure 33 is arranged at the inner side wall of the ring body 31. Corresponding to the center of the arc body 321, the reinforcing structure 33 is arranged recessing part 331. Corresponding to the arranging place of the arc body 321; that is, corresponding to the arranging place of

the recessing part 331, plural electrodes 34 are arranged around the ring body 31. A specific spacing distance D1 is arranged between the electrode 34 and the ring body 31. When the ring body 31 generates an elliptical resonance mode with 45 degrees difference due to the operation of Coriolis force, the reinforcing structure 33 may enhance the partial rigidity for the ring body 31. By arranging the recessing part 331, it is easy to maintain the device in elliptical resonance mode. During real operating state, the deformation of the ring body 31 may be extremely tiny. To clearly demonstrate the elliptical resonance mode of the ring body 31 in Fig. 6, the ring body 31 is compressed intentionally. Thereby, the value of capacitance is changed due to the variation of the spacing distance D1 sensed by electrodes 34, so it may obtain the tilt or rotary angular velocity of the carriers that are installed with the vibratile ring-shaped gyroscope 30. Additionally, the spacing distance D1 arranged between the electrode 34 and the ring body 31 is an optimal spacing distance designed according to the vibratile ring-shaped gyroscope 30. The spacing distance D1 may make the ring body 31 and the electrodes 34 have a closest distance that will keep from touching the electrodes 34 when the ring body 31 vibrates.

Please refer to Fig. 7, wherein the vibratile ring-shaped gyroscope 130 is comprised of a ring body 131 and supporting structures 132 arranged at two axial sides of the ring body 131. The supporting structure 132 includes a continuous ring-shaped body 1321. There is connecting part 1322 arranged equidistantly between the ring-shaped body 1321 and the ring body 131. At the intersection of a side, far from the ring body 131, of the ring-shaped body 1321 and the said connecting part 1322, a connecting part 1323 is arranged. The connecting part 1323 may connect the ring-shaped body 1321 fixedly to the base (not shown in the figures). Therefore, the entire vibratile ring-shaped gyroscope 130 is arranged in the base. Since the ring body 131 is connected to the ring-shaped body 1321 by the connecting part 1322 in points' manner to make the ring body 131 fixed between upper and lower supporting structures 132 with suspending arm type, so it may maintain the ring 131 to have a specific allowance of radial deformation and vibration.

To enhance the partial rigidity of the ring body 131 and maintain an elliptical resonance mode, there is a reinforcing structure 133 arranged at the

inner side wall of the ring body 131. The reinforcing structure 133 is a fin-like structure projecting out radially in equal width from the center of the inner side wall of the ring body 131. Corresponding to the connecting part 1322 between the arc body 1321 and the ring body 131, the reinforcing structure 133 is arranged recessing part 1331 that is shown as opening gradually divergent outward from the ring body 131 in side radial direction.

Please refer to Fig. 8. The structure of this vibratile ring-shaped gyroscope 230 is substantially same as that of the embodiment of Fig. 4. The vibratile ring-shaped gyroscope 230 is comprised of a ring body 231 and a supporting structure 232 arranged at two radial sides of the ring body 231. The supporting structure 232 is constructed by equidistantly arranging plural arc bodies 2321 having the same radius as that of the ring body 231 at two axially corresponding side edges of the ring body 231. Surrounded by the arc bodies 2321, a ring-shaped contour is constructed. The length of the arc body 2321 is slightly shorter than that of the arc body 321 shown in Fig. 4. At least one connecting part 2322 is arranged between each arc body 2321 and the ring body 231. The connecting part 2322 may make the arc body 2321 connected integrally to the ring body 231. A connecting part 2323 is further arranged respectively at two ends of one side, far from the ring body 231, of each arc body 2321. Connecting the arc body 2321 securely to the base (not shown in the figure) by the connecting part 2323, the entire vibratile ring-shaped gyroscope 230 may be arranged in the base. The ring body 231 is connected to the arc body 2321 by the connecting part 2322 in points' fashion, such that the ring body 231 is fixed between upper and lower supporting structures 232 in a suspending arm type, so it may restrain the ring body 231 from upward and downward motions, but it still may maintain the ring body 231 to have a predetermined radial deformation and vibration.

To promote the partial rigidity of the ring body 231 and maintain an elliptical resonance mode, a reinforcing structure 233 is arranged at the inner side wall of the ring body 231. The reinforcing structure 233 is a fin-shaped structure radially projecting out with equal width from the center of the inner side wall of the ring body 231. Corresponding to the connecting part 2322 between the arc body 2321 and the ring body 231, the reinforcing structure 233 is arranged recessing part 2331 shown as opening

gradually divergent outward from the ring body 231 in side radial direction. The difference between this recessing part 2331 and the recessing part 331 shown in Fig. 4 is that the connecting part of both recessing part 2331 and ring body 231 forms a spacing distance D2 at the inner side wall of the ring body 231 such that, when the ring body 231 generates elliptical resonance mode, the reinforcing structures at two sides of the recessing part 2331 will not interfere with each other.

Please refer to Fig. 9 and Fig. 10, wherein the vibratile ring-shaped gyroscope 330 is comprised of a ring body 331 and supporting structures 332 arranged axially at two sides of the ring body 331. The supporting structure 332 is constructed by plural arc bodies 3321, having the same radius as that of the ring body 331, arranged equidistantly and axially at two corresponding side edges of the ring body 331. Its state may refer to the embodiment of Fig. 3. The continuous ring-shaped body 1321 shown in Fig. 7 may replace the arc body 3321. Their achievable functions are the same. At least one connecting part 3322 is arranged between each arc body 3321 and the ring body 331. The connecting part 3322 may make the arc body 3321 connected integrally to the ring body 331. A connecting part 3323 is arranged respectively at two ends of one side, far from the ring body 331, of each arc body 3321. The connecting part 3323 may connect the arc body 3321 securely to the base (not shown in the figures). Therefore, the entire vibratile ring-shaped gyroscope 330 is arranged in the base. Since the ring body 331 is connected to the arc body 3321 by the connecting part 3322 in points' fashion to make the ring body 331 fixed between both upper and lower structures 332 in suspending arm type, so it may restrain the ring body 331 from upward and downward motions, but it may still maintain the ring body 331 to have a radial deformation and vibration with specific allowance.

To promote the partial rigidity of the ring body 331 and maintain an elliptical resonance mode, a reinforcing structure 333 is arranged at the inner side wall of the ring body 331. The characteristic of the reinforcing structure 333 is that the reinforcing structure 333 is a full-height type and has a height H2 same as that of the ring body 331, such that the reinforcing structure 333 may cover the inner side wall of the ring body 331. Corresponding to the connecting part 3322 of both arc body 3321 and ring

body 331, the reinforcing structure 333 is arranged a recessing part 3331 shown as opening divergent outward from the ring body 331 in side radial direction. One characteristic of this embodiment is that, corresponding to the arranging place of the recessing part 3331, electrodes 334 may be arranged at the inner and/or outer sides of the ring body 331. The electrode 334 has a height H3 that is same as the height H2 of both ring body 331 and reinforcing structure 333. Thereby, it may make the electrode 334 and the ring body 331 have a fully driving and sensing effective area. The promotion of effective inducing area is beneficial to lower down the needed driving voltage (energy) and increase the sensing signal-to-noise ratio simultaneously. Furthermore, since electrodes 334 may be arranged at both inner and outer sides of the ring body 331, so the driving and sensing efficacy of the invention is almost twice as large as that of the traditional device that arranges electrode at only one side.

In summary, the invention is to arrange a supporting structure at the axial sides of the ring body. Thereby, axial and radial supporting forces are provided between the ring body and the base to restrain the main vibratile ring body, such that the gyroscope according to the invention has preferable sensing sensitivity and the capability to resist environmental vibration and noise. In addition, reinforcing structures are arranged at the inner side and/or outer side of the ring body to promote the partial rigidity of the ring body and maintain an elliptical resonance mode. If the reinforcing structure is arranged as high as the ring body, then it is possible to arrange electrodes inside and outside the ring body to promote its driving and sensing efficacy, so the invention obviously possesses the novelty and industrial applicability; however, the above descriptions are only preferable embodiments of the invention and can't be regarded as the limitation of the invention, so any equivalent variation and modification made by those who are skilled in such arts according to the appended claims of the invention still possess the merits of the invention and also don't depart from the spirits and scopes of the invention, so they should all be regarded as further executing situations according to the invention.